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Risk analysis and economic viability of water harvesting for supplemental irrigation in semi-arid Burkina Faso and Kenya

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Abstract

Food insecurity affects a large portion of the population in sub-Saharan Africa (SSA). To meet future food requirements current rainfed farming systems need to upgrade yield output. One way is to improve water and fertiliser management in crop production. But adaptation among farmers will depend on perceived risk reduction of harvest failure as well as economic benefit for the household. Here, we present risk analysis and economical benefit estimates of a water harvesting (WH) system for supplemental irrigation (SI). Focus of the analysis is on reducing investment risk to improve self-sufficiency in staple food production. The analysis is based on data from two on-farm experimental sites with SI for cereals in currently practised smallholder farming system in semi-arid Burkina Faso and Kenya, respectively. The WH system enables for both SI of staple crop (sorghum and maize) and a fully irrigated off-season cash crop (tomatoes). Different investment scenarios are presented in a matrix of four reservoir sealants combined with three labour opportunity costs. It is shown that the WH system is labour intensive but risk-reducing investment at the two locations. The current cultivation practices do not attain food self-sufficiency in farm households. WH with SI resulted in a net profit of 151–626 USD $year^{-1}$ ha^{-1} for the Burkina case and 109–477 USD $year^{-1}$ ha^{-1} for the Kenya case depending on labour opportunity cost, compared to −83 to 15 USD $year^{-1}$ ha^{-1} for the Burkina case and 40–130 USD $year^{-1}$ ha^{-1} for the Kenyan case for current farming practices. Opportunity cost represents 0–66% of the investment cost in an SI system depending on type of sealant. The most economical strategy under local labour conditions was obtained using thin plastic sheeting as reservoir sealant. This resulted in a net profit of 390 and 73

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USD $year^{-1}$ ha^{-1} for the Burkina Faso and Kenyan respective site after household consumption was deducted. The analysis suggests a strong mutual dependence between investment in WH for SI and input of fertiliser. The WH system is only economically viable if combined with improved soil fertility management, but the investment in fertiliser inputs may only be viable in the long term when combined with SI.

Keywords: Water harvesting; Supplemental irrigation; Semi-arid; Labour cost; Cost–benefit

1. Introduction

It is widely recognised that a high level of uncertainty typifies the lives of people in smallholder farm households in developing countries. Unpredictability of climate, unstable markets and insecurity due to social, economic and/or adverse state political vagaries are important factors in insecure environments. Poverty further accentuates these uncertainties, meaning that the outcomes of uncertain events can often make the difference between survival and starvation. Food security, or rather the lack of it, is an issue generating increasing attention, especially in drought prone regions. The increase in food production in sub-Saharan Africa (SSA) during the last decade derives primarily from the expansion of agricultural land, i.e., bringing new land under production (World Bank, 1989; Rockström and Ada, 1993; Matlon, 1990; Hofwegen and Svendsen, 2000). Despite expansion of agricultural land, food production lags behind population growth (IFPRI, 2001). The virgin land taken into production is often marginal and is cultivated with low use of inputs (regarding labour as well as cash investment). For example, sorghum yields on marginal lands in northern Burkina Faso (Yatenga region) generally range from some 200 kg to a maximum of 700 kg ha^{-1}, unless yield-improving measures are applied (CNRST/INERA, 2000; Niemeijer and Mazzucato, 2002). The increase in population does not allow for fallow periods to be included in the crop rotation (Lund, 1998). Rainfed agriculture remains the main food producing activity in SSA (Alexandratos, 1995).

Generally, it is stated that water availability is the primary limiting factor for crop growth in the tropical semi-arid environment in SSA such as the Sahel (Lal, 1991). However, low annual or seasonal rainfall is not necessarily the critical constraint in crop production, but rather the irregular occurrence of rainfall events (Sivakumar and Wallace, 1991). This is one explanation for the large yield variation in dryland farming systems (Rijks, 1986; Rockström and Falkenmark, 2000). In addition, research indicates that soil nutrient deficiency is often equally or more limiting to crop growth than water in semi-arid farming systems (Klaij and Vachaud, 1992; Breman et al., 2001; Fox and Rockström, 2003). Water and nutrients thus interact in limiting crop growth. As water availability is the random factor of the two, it is thereby the key factor determining risk perceptions of harvest loss among farmers. The risk in turn will affect the decision to invest in inputs such as fertiliser, weed and pest management.